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Smart Vehicle Registry using IOT and Image Processing

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Abstract: ***In the current technological era, everything is getting automated through various technologies. There always remains a need for a Smart Vehicle Registry with optimized performance and zero human interference. This paper deals with such a system by incorporating RFID (Radio Frequency Identification) technology and Image Processing into a single automated system that registers every vehicle and the person driving the vehicle entering into a specific zone. This paper outlines a survey on various works that had been done on the field of RFID and Image processing. The proposed system deals with an RFID system that can be used to scan the person driving the vehicle and an Image processing system which consists of a camera and an open source library to scan and record the vehicle registration plate number and a front end to manage the input and output flow of the system. The system discussed in this paper is created in such a way the analysis can be easily performed on the output data. This paper also discusses the various outcomes and futuristic works that can be performed to improve the system.***

Keywords: RFID, MFRC522, OCR, Arduino, Jumpers, Bread Board, Servo motor, IDE.

I. INTRODUCTION

Smart Vehicle Registry is an automated system that manages the entry and exit of a vehicle entering into a zone. This system is achieved by implementing RFID (Radio Frequency Identification) technology and Image processing together. This system is implemented using a gate or toll like environment at the starting and ending of a zone or specific region. Each time a person enters or exits the zone or region, the RFID tag of the person is scanned If the person is authorized, then that person is allowed to enter or exit the zone or region. Simultaneously, the registration plate of the vehicle with which the person enters or exits is scanned using an Image Processing technique known as OCR (Optical Character Recognition). As soon as both the processes are done, the gate either opens or remains closed depending upon the authorization. The system is developed in such a way that analysis can be performed easily and any fraudulent entries can be identified and necessary actions can be undertaken. The data can be analyzed in such a way that fruitful information and patterns can be found to develop the system.

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II. LITERATURE SURVEY

Many researchers and engineers have developed and incorporated many technologies to provide an automated system that provides authenticated access and analysis of data. Orji et al [1] has developed an Automatic Access Control System to provide restricted and authorized access using RFID and Arduino. Once the RFID tag of a person is scanned by the RFID reader, it checks for the authentication by matching the UID of tag with the same on the database entries which consists of the list of authorized UID [1]. If matches, the person is given authorized access or else the person's access is denied. This system is achieved using a simple RFID reader and a tag and few communication devices like an Arduino board and a computer to configure the data into the tag and to the database. An Office Intelligent Access Control System was proposed and developed by Xiaoxu et al [2]. This system allows only authorized access into an office through a process. A staff willing to enter the office premises is made to check for authorization. The entry door is locked and the staff scans his RFID tag in a reader placed near the door. Once scanned the electronic clock responds along with a voice or an alarm. If the staff is authorized personnel, then the electronic lock opens and a voice occurs from gate saying access granted or an access tone and the gate opens [2]. If the staff is not authorized personnel, then the electronic lock remains closed and alarm occurs. This system is implemented with the help of an RFID reader and tags, Electronic lock, Magnetic gate and communication devices to configure the system. Cheng et al [3] proposed a License Plate Recognition mechanism using a hierarchical methodology. In this methodology, the vehicles are detected using the deep learning techniques as the first step. Then the plates are retrieved from the detected vehicles to reduce false positives and finally the characters are recognized using LPR Convolutional Neural Network which achieves an overall 99.2% of character recognition accuracy [3].

Fie et al [4] proposed a Robust License Plate Detection and Character Recognition Algorithm based on a Combined Feature Extraction Model and BPNN. This system is adaptable in weak illumination and also in complicated backgrounds. As a conventional process, the first step is to preprocess the image to strength the contrast and filter the image. Next the license plate localization is performed using integral projection method. Then feature extraction is performed by training the vectors through BPNN to complete accurate recognition of license plate characters. This is designed using three sets of feature combinations.
This method has achieved an increasing accuracy of 97.7% with decreased consuming time [4].

III. METHODOLOGY

The proposed system is an automated system which registers the entry and exit of a vehicle into the specific zone or region. The first process of the system is to check authenticity by scanning the driver's RFID tag using a RFID reader such as MFRC522. If access is authenticated then the driver's personal data flows into the front-end screen in a responsive way. The next step is to scan the vehicle's registration plate which is done simultaneously with the first process. In this process the number plate is scanned, recognized and stored digitally and flows into the front-end. If the access is authorized and once the plate recognition is complete, the gate opens and the vehicle is allowed to pass through. If the access is denied then the data doesn't flow into the front end and the gate doesn't open. The entire process is depicted below:

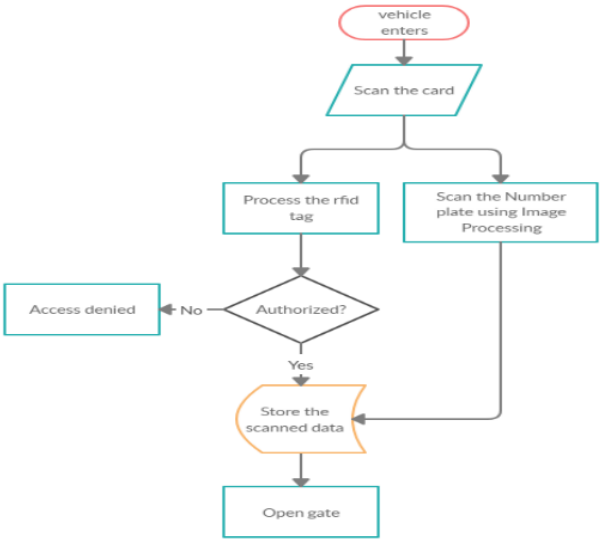

Fig. 1. Implementation steps of the proposed system

IV. RFID TECHNOLOGY

This is the first part of the project is to implement the RFID technology to check the authorization of the person entering the specific zone or region.

A. Hardware Overview

The Hardware consists of an RFID Tag, MFRC522 RFID reader, a Bread Board, A Servo motor, few Jumper wires and an Arduino Uno board. The Arduino board is connected to MFRC522 RFID reader with the prescribed pin configuration of MFRC522 with Arduino Uno. The servo motor is also connected with the Arduino Uno Board.

- RFID Tag: RFID tags uses the radio frequency technology of RFID to transmit data to and receive data from an RFID reader. It works by using smart barcodes by transmitting and receiving information via an antenna and a microchip. The battery-operated RFID tags contains an inbuilt battery as power supply whereas the passive RFID tag works by electromagnetic energy transmitted from an RFID reader.

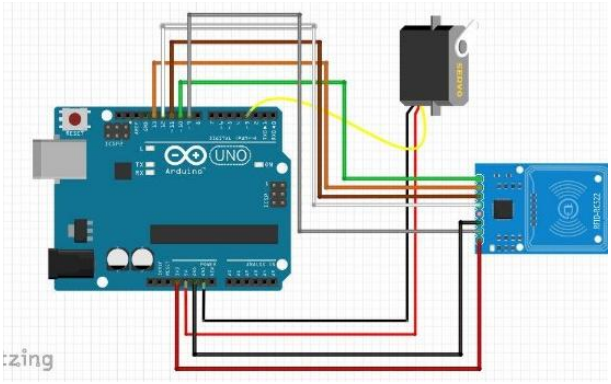

Fig. 2. Circuit Diagram of RFID Technology

Fig. 3. RFID Tags

- MFRC522 RFID Reader: MFRC522 IC is an RFID Reader module. This Reader module creates a 13.56MHz electromagnetic field that communicates with RFID tags. The reader can also communicate over a 4-pin Serial Peripheral Interface (SPI) and also over I2C and UART protocols [5]. The module contains an interrupt pin. The operating voltage of the module starts from 2.5V and it operates up to 3.3V.

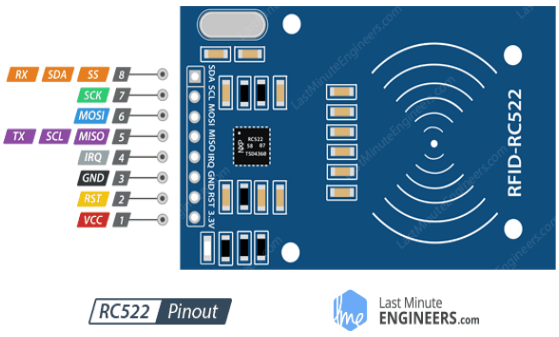

Fig. 4. MFRC522 IC Layout [5]

- Arduino Uno: Arduino Uno is an open source microcontroller board which consists of sets of digital and analog I/O.

The board has 6 analog I/O pins and 14 digital I/O pins. It can be powered by an USB or an external power source ranging from 7 to 20 volts and it is the first of its series. The Uno communicated over STK500 protocol

- Servo Motor: A servo motor is an electrical device which is used to rotate an object at a specific angle

Fig. 5. Arduino Uno SMR R3 [6]

Fig. 6 .Servo Motor [7]

[7]. It is a closed loop system and it uses a positive feedback system and controlled by this feedback by comparing output and input signals. The main task of the servo mechanism is to maintain output of the system at the presence of noise. Servo motor is either DC or AC. It works on Pulse Width Modulation.

B. Software Overview

Arduino Board is a microcontroller board which can be programmed to perform tasks. Arduino IDE is an IDE (Integrated Development Environment) which is used to program the Arduino Boards by writing sketches and uploading the same to the board. The programming of an Arduino is based on C/C++ programming languages. A sketch needs only two functions to run. A setup function which is used to initialize variables and other necessary properties. A loop function where actual programming is written and is runs continuously until the board is powered off.

C. Working of the System

The RFID Reader module MFRC522 is connected with the Arduino Uno along with the Servo motor. The Arduino is first programmed to write personal data into the RFID tag and to store the UID of the tag into the database. It is compiled and uploaded into the board. Then the Arduino is made to run and personal data of a person is configured into the RFID tag and the UID is entered into the authorized entries in the database. After the process the RFID tags are issued to the concerned people. Then the MFRC522 is programmed to allow people with authorized RFID cards to pass the gate. As discussed, a driver places the RFID tag on a reader and if it is an authorized entry the personal data flows into the front-end form. If it is an unauthorized access, then the data doesn't flow into the front-end and the access is denied.

V. VEHICLE REGISTRATION PLATE RECOGNITION

The other part of the system is to recognize the Registration Plate of the Vehicle which also flows into the front end and then the gate finally opens if the access is authorized which is identified in the first part of the system. The flow of this process is depicted below:

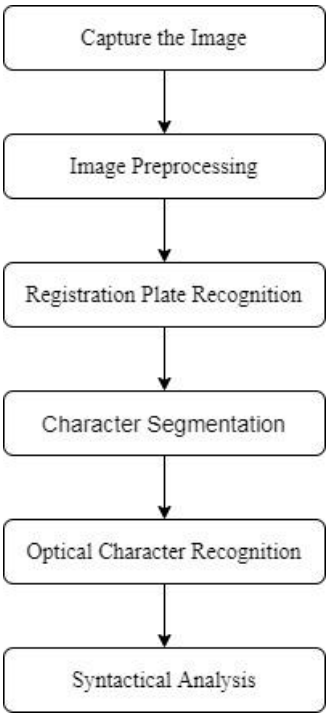

Fig. 7. Flow of Vehicle Registration Plate Recognition

A. Capturing the Image

A Camera is placed at the environment at a position convenient for capturing the Vehicle's Registration plate. This camera captures the images and send to the front end as a live feed. These captured images are used for recognition. An HD camera can be used and for a prototype a computer's web camera can server the purpose.

B. Image Preprocessing

Various Image Preprocessing techniques are employed to remove noise, normalizing the intensity, reducing background data and much more to make it ready for recognition. This technique is very necessary in order to recognize the characters accurately. Various techniques such as resizing the image, gray scaling the image, median filter.

Image Resizing: Image resizing is the first necessary step to be performed as the captured image may be of different ratio and it also contains unwanted background noise. Image cropping is a very suitable solution for this process. Either we can do it manually which involves a lot of human work and time or we can automate it by implementing certain steps like the one proposed by Jianzhou et al [8] which is based on an Aesthetics-based which gives importance to certain factors such as the cropped area, crop boundary , composition of the initial image to the final image. Many candidates of crops have been selected and a composition score is evaluated based on the above-mentioned factors to get the final crop [8].

Fig. 8. Resized Image [9]

- Gray-scale Image: The cropped image should be converted to grayscale in order to recognize the characters. This grayscale images loose contrast, sharpness, structure of the color image and shadow. Saravanan et al [10] proposed a new algorithm that preserves all the above-mentioned factors by performing RGB reduction, approximation and addition of chrominance and luminance at a minimum amount of time.
- Median Filter: This technique is very essential pre-processing technique as it removes the noise for edge detector to get accurate outputs. It is a non-linear digital filtering technique. The algorithm works entry by entry in a signal and it replaces each entry with the median of the neighboring entries [12]. Youlian et al [13] proposed an improved median filter algorithm which reduces noise and retains the details of the image. This algorithm processes the features of the filtering mask over the image by using the correlation of the image.

Fig. 9. Grayscale Image [11]

D. Registration Plate Localization

Registration plate localization is the most important step of this process as it extracts the plate out of the image using various methods such as edge detector, Hough transforms, binary conversion, morphological operations. For this process we use an edge detection algorithm called Canny edge detector. This operator uses multi-stage algorithm to extract structural information from objects. It first applies a

Fig. 10. Edge Detected Image [16]

Gaussian filter to remove noise and finds the intensity gradients. Then to get rid of spurious responses it applies non-maximum suppression and then to determine potential edges it applies double threshold. Finally, it tracks edges by hysteresis [14]. Jun et al [15] proposed an improved Canny edge detection algorithm that provides a better and evident denoising effect. This algorithm improves the accuracy of positioning. It tweaks the original algorithm by replacing functions such as Gaussian function with B-Spline function. In this algorithm gradient histogram is used as the basis for selecting thresholds [15].

E. Character Segmentation

In order to recognize the text in an image, the characters of the text must be segmented in the image. The overall accuracy of the system depends on this step. The segmentation process is of threefold. The first task is to perform line segmentation which scans the image horizontally to construct row histogram by counting the frequency of black pixel in every row. If a position where the number of pixels in a row is entered as zero, then it represents the boundary between lines. The next task is to perform word segmentation which is similar to line histogram except it scans the image vertically to construct column histogram. If the number of pixels in a column is zero then it indicates the space between words. Finally, character segmentation is performed which at first finds the minimum frequency of the word, then connected component analysis is performed to find out the connected objects which helps to crop the individual character.

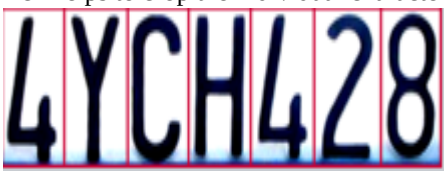

Fig. 11. Character Segmentation of Number Plate [17]

F. Optical Character Recognition

There are many algorithms that performs Optical Character Recognition (OCR). Since we are using a front-end Visual Basic, the Tesseract class of emgucv library can be used to perform OCR. Tesseract is a famous OCR engine developed at HP from 1985 to 1995 and then is being improved extensively by Google since 2006. The emphasis for the development of this engine has novel approach in classification, line finding and much more.

The classification of this approach is of two-step process or it can also deploy an adaptive classifier as OCR engines can benefit from it as it uses isotropic baseline/x-height normalization. This approach is very useful for differentiating upper- and lower-case letters [18]. A combined library which contains all these features is used to make the job easier. A C++ library named OpenALPR is used which has bindings for visual studio. OpenALPR is an open source library which uses Tesseract features and OpenCV tools to recognize image for different countries.

G. Syntactical Analysis

Since every country deploys its own rules in registration plates. Syntactical analysis is a key process to compare country specific rules. Since there may be a problem of similar shape characters which confuses the recognition, syntactical analysis may come in handy as it performs analysis of the linguistics and rules based on the geography of the region.

VI. RESULTS AND DISCUSSION

Initially the RFID system and the Image processing system works independently. But after working on their respective individual functions, both they system communicates and transfers the data to an interface. The RFID system as explained briefly will scan the RFID tag using an RFID reader to check if the person is authorized and transfers the necessary data to the interface.

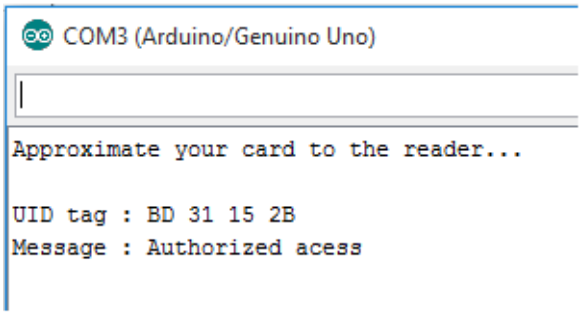

Fig. 12. Output screen in Arduino Console [19]

An Image processing system is implemented using an open source library named OpenALPR which is specifically used for recognizing text from vehicle registration number plates using OCR. This library is implemented in a Visual Basic Form using the OpenALPR bindings. A camera identification function is set up in order to identify the cameras available which gets preloaded to the main form as a list from which one is selected for use. The camera is calibrated before in order to fit the environment. The patterns and configuration of the number plates are entered into the library for fast post-processing. The OpenALPR recognizes the text once the vehicle number plates come into the camera's field of view. The Indian vehicle registration plate contains text as either a single line or a multi-line. However, this project initially aims at recognizing single line registration plates which is placed in the front side of most of the vehicles. The camera is calibrated based on this criterion. The overall accuracy of training and implementation phase is given below in the form of a table.

Table- I: Accuracy Table of Indian Plates vs Other Countries' Plates

Regions	Average Training Accuracy	Average Implementation Accuracy
India	92.1	91.7
Other Countries	95.7	93.9

After Recognizing, the text is entered into the form and the data from the RFID is also entered into the form the Arduino board from serial communication. After both the data gets entered, the data gets registered to the database along with a time stamp. There are also few buttons inside the form for manually entering the data into the database at certain situations.

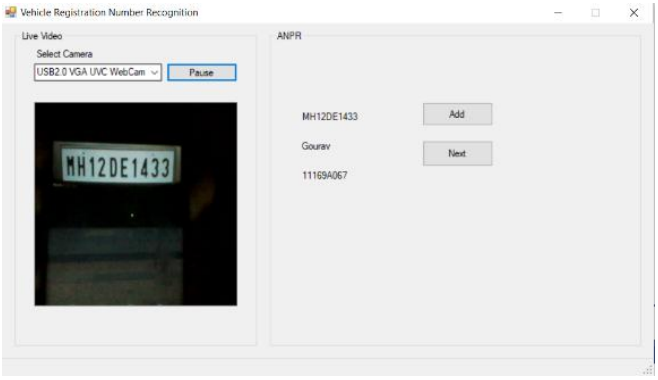

Fig. 13. Output Screen of the Interface

VII. CONCLUSION

This Smart Vehicle Register system is a very productive system at closed environments which makes the life of security personnel much easier. The proposed system was tested in an indoor as well as in an outdoor environment with a prototype. It was mainly created to work inside a closed corridor like a university and the results are very supporting for it. The system achieved great results with a decent accuracy as listed above. This system was mainly intended to work with Indian vehicles but it is not a limitation. This system also works with many countries across the globe. This system work with only single line registration plates of Indian vehicle. Many works can be done in the near future to extend the system to work with multi-line registration plates of the Indian vehicles and many alterations can be made to increase the accuracy of Indian registration plates. This system works fine for number plates which has text in formal font and also some designed fonts. Improvements can be made to recognize text that has more design elements which is hard to recognize easily even through naked eye. Overall this System is very dependable in a closed environment and analysis from these data can be extracted in a very efficient manner.

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